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How high school students represent the image of scientists in their minds

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Abstract

The purpose of this study is to explore high school students' images toward the physicists. Also, this study investigates whether any changes of these images occur among grade levels. For this aim, "Characteristics of a Physicist" questionnaire (CPQ) was developed by researchers. This questionnaire was completed by 220, 9th and 12th grade high school students. Convenient sampling was drawn from the high schools in Çankaya district of Ankara, Turkey. As a research methodology, quantitative and qualitative analysis were used. Themes and patterns were identified based on students' responses. Suggestions and implications were also discussed.

Keywords: nature of science , image and views, physicists, high school students

1. Introduction

Global development has created economical, societal and technological transformations and also brought new challenges for educational systems. Till now, governments have recognized these changes and many of them have attempted to renew their educational systems by considering demands of the 21st century. The need for scientifically literate people has emerged and science literacy is integrated into curriculum as one of the main goals of science education. In general, scientific literacy refers to understanding of the nature of science (NOS) and its concepts to make decisions about socio-scientific issues (Roberts, 2007). In other words, a scientifically literate person possesses general science knowledge and ideas about technological issues and can use this knowledge not only in formal settings but also in informal environment. This being the case, science education community recommends teaching NOS aspects such as developing correct views and images toward scientists and their works (Akerson, Abd-El-Khalick & Lederman, 2000; Schwartz & Lederman, 2002).

Researchers are still interested in studies related with images of scientists and it is not rare to see contemporary studies (Koren & Bar, 2009). This interest in the topic could be emanated from the changing learning approaches in science teaching and their reflections in curriculum and how it is perceived by students in recent years (e.g., Balkı, Çoban & Aktaş, 2003; Anderson, 2006; Güler & Akman, 2006; Türkmen, 2008). Teaching proper knowledge about scientific development, construction of scientific knowledge and the scientists as leading actors of science are very important for students to develop positive attitude toward science. Inside and outside of the school, students

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encounter with differently symbolized scientists' images (e.g. documentary films, science fiction books/movies, textbooks). These images can be considered as tools to investigate students' perceptions about science and scientists (Türkmen, 2008). However, studies on images of scientists are mostly conducted on elementary school students in Turkey.

Within almost four years, curriculum changes are completed with still ongoing improvements in Turkey. Nature of Physics (as a domain specific NOS) unit has been integrated into the high school physics curriculum through explicit and implicit instruction. Explicitly, NOS is discussed in the 9th and 12th grades as separate units, whereas implicit approach is integrated into other units with physics-technology-society-environment objectives. The current study aims to explore the 9th and 12th grade Turkish students' perceptions (views) about scientists and their working methods, as well as to document the similarities and differences among these groups.

The present study seeks to answer the following questions: (1) what kind of views do high school students hold about the physicists in their minds? (2) Are there any similarities and differences between 9th and 12th grade students' views about physicists?

2. Method

2.1. Sample

For the study, researchers selected two Anatolian high schools by convenient sampling. These schools are located in the centre of the Çankaya district in Turkey. In total, eight classes were randomly selected from 17 9^{th} and 12^{th} grade classes and 220 students (N_{male}=111 and N_{female}=109) participated voluntarily in the study. Descriptive statistics of the sample are given in terms of school, grade and gender in Table 1.

Table 1. School, grade and gender distribution of students

School	Grade level	Age Range	Gender		Total (%)
			Male	Female	
1	9	14-15	26	34	60 (27.2)
	12	17-19	42	33	75 (34.1)
2	9	14-15	29	31	60 (27.2)
	12	17-19	14	11	25 (11.5)

The data were collected in fall semester of year 2011. Data collection was scheduled among schools. The test was administered to classes within short time intervals. In each school, instruments were administered to the same grade levels at the same time. The duration of the test took approximately 20-25 minutes.

2.2. Instrument

For the study, researchers developed an instrument called as Characteristics of a Physicist Questionnaire (CPQ) which consisted of three parts. The first part of the instrument included 30 likert-type items which indicated three categories related with physicists' image: (1) personal characteristics of physicists, (2) working environment of physicists, and (3) how scientists contribute to scientific knowledge. In the second part, participants were expected to exemplify their favorite physicists. In the last part, participants were asked to draw a physicist, which was adopted from Draw-A-Scientists Test (DAST) developed by Chambers (1983).

2.3. Data Analysis

Students' responses in the first part were entered into IBM SPSS program and frequency analyses were conducted. Each subscale was scored with the mean value of associated items in the questionnaire. These scores were compared statistically within different grade levels. In addition to quantitative analysis, students' drawings (in the third part) were analyzed qualitatively in terms of supporting data obtained from the first part.

3. Results

3.1. Findings of CPQ

Students' responses on personal characteristics, the first category, associated with physicists were descriptively summarized under seven traits with percentages as presented in Table 2. Students tended to distinguish traits, such as superior prior knowledge, creativity, intuition and imagination, which were the distinctive features of physicists. As can be seen from the table, these perceptions did not show different trends among grade levels. In spite of the superiority of knowledge, only 34% of students responded as physicists were more knowledgeable than ordinary people in the society. Moreover, accountability of physicists was found to be very low among students' perceptions.

Table 2. Percentages of 9th and 12th grade students' responses about personal characteristics of physicists

Grade	Possess superior prior knowledge	Creative	Intuitive	Talented	More knowledgeable than ordinary people	Imaginative	People trust scientists
9	52	74	73	24	31	72	14
12	61	85	69	40	37	80	15
Total	60	79	71	31	34	75	15

Second category in the questionnaire revealed students' perceptions about physicists' working styles and their relationships with other physicists. As can be seen from Table 3, students' responses showed similar patterns for the items in this category. 71% of the students agreed on physicists' following steps of scientific method in their research which may differ among physicists. In average, only 11% of students attached experimentation into scientific methods as a vital element. Few students visualized physicists as popular individuals in their communities due to their scientific affiliations. The items related with social collaboration and cooperation showed that most of the students recognized physicists as social people who had more collaborative working skills. About 62% of the students perceived conflicts among physicists as a negative fact. At this point, it could be inferred that students valued agreement among physicists' ideas. However, these ideas were recognized as neither objective (41%) nor subjective (35%).

Table 3. Percentages of 9th and 12th grade students' responses about work environment of physicists

Grade	They follow similar methods	Popular Personalities in their communities	Tend to work alone	Antisocial character	Experiment	Objective in their research	Conflict weakens progress of science	Follow steps of scientific method	Subjective in their research
9	30	13	38	26	5	41	64	71	31
12	28	23	37	42	18	41	60	71	41
Total	29	18	37	33	11	41	62	71	35

The last category of the scale revealed students' views about scientific knowledge, especially at physics branch as shown in Table 4. In the 9th grade physics unit, Nature of Physics, the aspects of scientific knowledge has discussed thoroughly. However, almost half of the 9th grade students in the sample regarded scientific knowledge as certain. This image also reflected students' ideas on making best explanation as a requirement for successful physicists.

Table 4. Percentages of 9th and 12th grade students' responses about physicists' contribution to scientific knowledge

Grade	Influenced by already developed theories	Discover scientific knowledge	Try to make best explanation	They should not make mistake	Aim to find absolute truth	Variety of ideas enrich scientific knowledge	Aim to falsify previous findings	Scientific knowledge is tentative
9	72	68	67	40	73	61	18	45
12	72	72	75	57	74	72	25	60
Total	72	70	70	48	74	66	21	52

In addition to certainty of scientific knowledge, contributors of it were perceived as impeccable performers. In addition, 70 % of the students perceived physicists as discoverers. Therefore, findings in these categories were

consistent with each other and among both groups. Another point worth discussing is that students' images formed a picture of scientific knowledge as developed cumulatively by physicists. Pragmatic shifts were mostly ignored according to the findings (72%). This can also be seen from the category of "aim to falsify previous findings". According to second category, students identified "conflict" as a negative term. In spite of this image, students valued variety of ideas for development of scientific knowledge in the third category.

3.2. Students' favorite physicists

As a second part of the CPQ, participants were asked to exemplify their favorite physicists. Most of the 9th and 12th grade students stated Albert Einstein as their known-physicists. As an interesting finding, very few 9th grades stated their famous physicists as İbn-i Sina (1%) and Farabi (1%). The same findings were observed in 12th students' drawings. Feza Gürsey (3%) and Ali Kuşcu (1%) were a model in their minds as physicists.

Table 5. Percentages of 9th and 12th grade students' favorite physicists

Physicists	9th Grade (%)	12th Grade (%)
Albert Einstein	79	63
Isaac Newton	73	55
Galileo Galilei	57	30
Archimedes	18	17
Thomas Alva Edison	18	5
Marie Curie	15	9
Alexander Graham Bell	8	4
Blaise Pascal	8	15
Aristoteles	6	-
Nicola Tesla	5	16
Evangelista Torricelli	5	6
John Dalton	3	5
Stephen Hawking	2	13
Michael Faraday	-	10
Niels Bohr	-	9
Werner Heisenberg	-	7
Johannes Kepler	-	5
Henry Moseley	-	5
Max Planck	-	4

3.3. Results of "Draw a Physicist" Section

Participants were asked to draw a physicist in the last part of the CPQ. In this part the students' images of physical and personal characteristics of physicists and their working environments were investigated deeply. The results related with physical characteristics of physicists were presented in Table 6 according to 9th and 12th grades. As indicated in the table, no considerable difference was found among 9th and 12th students' images of personal characteristics of physicists. Unlike stereotype image of scientists as being only male, 22 of 9th and 12 of 12th grade students depicted physicists as a female. Both 9th and 12th grade students thought that physicists had to be clever, disciplined, greedy, systematic, experimenter, observer, curious, objective, sensible, responsible, patient, brave, researcher and careful. In addition, 9th graders represented negative images about physicists as being nervous, evil and anti-social. Some 12th grade students added other personal characteristics to physicists. They considered that physicists had to be productive, sophisticated, professional, creative, perceptive, enhancer and humanist. Additionally, some 12th grade students believed that physicists were anti-social and insomniac persons.

9th graders represented physicists while working in a laboratory, using computers and traditional lab instruments (such as tubes, paper and pencil, magnet, telescope, ruler and balance). 12th grade students introduced their images

of physicists as experimenting in a laboratory, using some tools such as lens, elevator, physics books, magnets, ammeter and pendulum.

Table 6. Images of 9th and 12th grade students about the physical characteristics of physicists

	Grade 9	Grade 12
Physical characteristics	Messy- haired	Curved, messy-haired
	Rough hair and with earning	Rough hair and with earning
	No hair or long hair	No hair
	Wearing eye glasses	Wearing eye glasses
	Mostly male	Mostly male
	Wearing lab-coat	Wearing lab-coat
	With a moustache and beard	With a moustache
	Spot on face, pimply	Spot on face
	Smoker	Smoker
	Fat	Fat
	Messy	Have a tie, in the suit
	Scowler	Muscled
	Like a crazy	Like a crazy
		Dressing gown or turbaned

4. Discussion

The results of this study supported the findings of previous research in terms of some aspects. For example, a physicist as a scientist was mostly male, intellectual, curious and mostly spending time in laboratory (e.g., Chambers, 1983; Türkmen, 2008). This study did not find any differences among grade levels in terms of students' image of physicists. Most participants did not depict physicists as a natural, typical and realistic person. As indicated above, the image of physicists was an important part of physics education with the new physics curriculum. NOS topics included physicists and their works. Therefore, this study suggests that teachers, science teacher educators and textbooks' writers to be more sensitive about these issues. Interestingly, although most of the students exemplified known physicists as Albert Einstein, some of them gave an example of both contemporary foreign and Turkish physicists such as Stephen Hawking, Feza Gürsey and Ali Kuşçu. As a limitation, our study conducted in only two schools in one of the cities of Turkey. Following studies can be extended to further populations. In addition, students' images about the physicists can be investigated by using interview techniques for providing more comprehensive results.

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